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AUTHOR Shubert, L. Elliot
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ABSTRACT

This report is a compilation of presentations made at a symposium which focused on various topics and issues related to the current status of science and mathematics education at the national, state, and local levels. These presentations are: (1) "Growing Recognition of a Serious National Problem in Science Education" by M. Joan Parent (examing the working of the National Science Board Commission, including Commission findings about the teaching profession, science curricula, science equipment, and such new technologies as microcomputers); (2) "The Science Education Debate in Congress" by Douglas R. W. Norell; (3) "Science Curriculum: From Sputnik to the Toyota" by Vito Perrone; (4) "Science Education: Trends in North Dakota" by Donald R. Scoby (discussing the science methods class at North Dakota State University and presenting data on the numbers of mathematics and science education majors at North Dakota colleges and universities, 1972-1982); and (5) "The Rise and Fall of Twenty-Five Years of Science Education: 1958-1982" by Clarence E. Thompson (including information on teaching high school science at Grand Forks Central High School and data comparing achievement of 127 students at the school to 6,589 students throughout the state). (JN)

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INSTRUCTIONAL DEVELOPMENT REPORT

Science Education: An Emerging Crisis

Edited by
L. Elliot Shubert
University of North Dakota

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Editor's Introduction

This Instructional Development Report is a compilation of presentations made at a symposium, "Science Education: An Emerging Crisis," which was part of the North Dakota Academy of Science meetings held at the University of North Dakota, April 28-30, 1983. The purpose of this symposium was to present an overview on math-science education at the national, state and local levels. The symposium was timely, since Congress was actively debating bills to fund math-science education programs and the National Commission on Excellence in Education just released their report, "A Nation at Risk."

The views and opinions expressed in this symposium about the problems and possible solutions for math-science education in our public schools are varied. However, there was general agreement that we have a problem and that it must be solved if the United States expects to be in the forefront of science and technology in the twenty-first century.

I appreciate the ideas and encouragement I received from many of my colleagues that resulted in this symposium. In particular, I would like to express my gratitude to Robert Young, Director, Office of Instructional Development, UND for providing his ideas, and moral and financial support for the symposium and this publication. Also, I appreciate the advice and encouragement from A. William Johnson, Dean, Graduate School, UND, and Secretary-Treasurer, North Dakota Academy of Science. Part of the publications costs were supported by the North Dakota Academy of Science. Special thanks are due to Brenda Tweten for helping with the organization of the symposium and the typing of the manuscripts.

I hope the ideas from this symposium will foster a continuing forum among educators, administrators, and legislators about the national importance of maintaining effective math-science education programs in our public schools.

L. Elliot Shubert,
Moderator

A NATION AT RISK

THE INDICATORS

- International comparisons of student achievement, completed a decade ago, reveal that on 19 academic tests American students were never first or second and, in comparison with other industrialized nations, were last seven times.

- Some 23 million American adults are functionally illiterate by the simplest tests of everyday reading, writing and comprehension.

- About 13 percent of all 17-year-olds in the United States can be considered functionally illiterate. Functional illiteracy among minority youth may run as high as 40 percent.

- Average achievement of high school students on most standardized tests is now lower than 26 years ago when Sputnik was launched.

- The College Board's Scholastic Aptitude Tests (SAT) demonstrate a virtually unbroken decline from 1963 to 1980. Average verbal scores fell over 50 points and average mathematics scores dropped nearly 40 points.

- College Board achievement tests also reveal consistent declines in recent years in such subjects as physics and English.

- Many 17-year-olds do not possess the "higher order" intellectual skills we should expect of them. Nearly 40 percent cannot draw inferences from written material; only one-fifth can write a persuasive essay; and only one-third can solve a mathematics problem requiring several steps.

- Average tested achievement of students graduating from college is also lower.

- Business and military leaders complain that they are required to spend millions of dollars on costly remedial education and training programs in such basic skills as reading, writing, spelling and computation. The Department of the Navy, for example, reported to the commission that one-quarter of its recent recruits cannot read at the ninth-grade level, the minimum needed simply to understand written safety instructions. Without remedial work they cannot even begin, much less complete, the sophisticated training essential in much of the modern military.

THE RECOMMENDATIONS

CONTENT: We recommend that state and local high school graduation requirements be strengthened and that, at a minimum, all students seeking a diploma be required to lay the foundations in the Five New Basics by taking the following curriculum during their 4 years of high school: (a) 4 years of English; (b) 3 years of mathematics; (c) 3 years of science; (d) 3 years of social studies; and (e) one-half year of computer science. For the college bound, 2 years of foreign language in high school are strongly recommended in addition to those taken earlier.

STANDARDS AND EXPECTATIONS: We recommend that schools, colleges and universities adopt more rigorous and measurable standards, and higher expectations, for academic performance and student conduct, and that 4-year colleges and universities raise their requirements for admission.

TIME: We recommend that significantly more time be devoted to learning the New Basics. This will require more effective use of the existing school day, a longer school day, or a lengthened school year.

SOURCE: THE NATIONAL COMMISSION ON EXCELLENCE IN EDUCATION

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LIST OF PARTICIPANTS

Douglas R. W. Norell
Senior Legislative Assistant
Office of Representative Byron Dorgan
238 Canon Building
Washington, D.C. 20515

M. Joan Parent
President
National School Boards Association
R.R. 4
Foley, MN 56329

Vito Perrone
Dean
Center for Teaching and Learning
University of North Dakota
Grand Forks, ND 58202

Donald R. Scoby
Professor
Department of Botany/Biology
North Dakota State University
Fargo, ND 58105

L. Elliot Shubert
Associate Professor
Department of Biology
University of North Dakota
Grand Forks, ND 58202

Clarence E. Thompson
Biology Teacher
Science Department
Central High School
Grand Forks, ND 58201

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GROWING RECOGNITION OF A SERIOUS NATIONAL PROBLEM

M. Joan Parent
President, National School Boards Association

Introduction

Senator Chiles of Florida recently said, "It looks like having a math and science bill has become a requirement for membership in the U.S. Senate this year," and promptly dropped one in the hopper himself. Over 100 bills have been introduced in the House of Representatives to improve math and science education in our schools, and one--HR 1310--has passed with overwhelming support from both parties. The Senate expects to pass a bill by June. The President called for upgrading math and science instruction in his State of the Union message this year.

Two Federal commissions are looking at the problem--the Commission on Excellence, appointed by Education Secretary Terrel Bell, and the National Science Board Commission on Precollege Education in Mathematics, Science and Technology, on which I serve, chaired by Dr. Cecily Selby and William Coleman. Dr. Selby is Chairman of the Board of Advisors of the North Carolina School of Science and Mathematics, and Mr. Coleman, former Secretary of Transportation, is a senior partner in a Washington law firm.

The American Association for the Advancement of Science has formed a Coalition on Education in the Sciences and is now putting out a monthly newsletter, Science Education News, to try to keep groups informed about what is happening. The Carnegie Corporation recently convened a "Group of 50" distinguished national leaders to consider the nation's education needs in relation to the economy, focusing especially on math and science, and has already issued recommendations.

Scarcely a Governor failed to mention the declining quality of education, especially math and science, in their state-of-the-state messages this year. Governor Hunt of North Carolina, who now chairs the Education Commission of the States, has a Task Force on Education for Economic Growth, on which I also serve, and we will issue our recommendations in early May. Meanwhile, he has urged every Governor to declare 1982-83 the year of the public school. Many states have recently enacted or are now debating proposals that affect the quality of their math and science education at the elementary and secondary levels. This is taking place despite the severe budget problems faced by the states, nowhere more so than here in North Dakota.

What is happening? Is this concern justified? Will anything come of all this activity? What bearing does it have on higher education?

What we are seeing is a growing awareness that our schools are having serious trouble turning out kids who are either informed about or interested in math or science. At the next level, our colleges and universities are having serious trouble turning out teachers who want to teach math and science. The two are not unrelated. It isn't easy to learn from a teacher who doesn't know the subject, and there is evidence that as many as half of the current high school math and science teachers fit this description. Nor does learning math from the basketball coach usually produce the highest level of interest in math, although it may give the team a boost.

With fewer kids coming out of high school who want to study math and science and fewer who want to become teachers of any subject, and industry hiring away those who are teaching with higher salaries, the problem of getting enough well-qualified math and science teachers is getting worse all the time. They just aren't in the pipeline. Concern is increasing that the precollege student's understanding of these subjects is going to get worse before it gets better.

Meanwhile, society is changing rapidly. As David Hamburg of the Carnegie Corporation commented at a recent meeting of Governor Hunt's Task Force, 75 to 80 percent of the scientists who have ever lived are alive today. Our lives are vastly different from those of our parents' generation. The cost of microcomputers is now cut in half almost every two years, a productivity increase never known before. The nation and the 50 states are rapidly coming to the view that the wave of the future is science and technology and the principal resource needed to produce it and use it is well-educated human beings. Economic concerns are foremost in people's minds, but the strength or our defense establishment is not far behind.

Work of NSB Commission

I would like now to tell you about the work of the National Science Board Commission, where we seem to be headed, and some of the implications for action on a national level and on the part of our institutions of higher education.

The Commission was established by the National Science Board, which is the policymaking body of the National Science Foundation, because the Board believed it was time to take a fresh look at math and science education at the elementary and secondary levels.

The reasons for this are not hard to find:

--One-half of all our high school graduates take no math beyond 10th grade,

--Science achievement scores of 17-year olds have declined steadily since 1969 as measured in three national assessments by the Education Commission of the States,

--Undergraduate enrollment in remedial mathematics increased 72 percent between 1975 and 1980, while total enrollment increased only 7 percent.

--In a recent study, 42 percent of U.S. 17-year olds were unable to solve the problem: 30 is what percent of 60?

84 percent were unable to solve the problem: 6 is what percent of 120?

--In two international studies, Japanese students significantly outperformed others, including those of the U.S., in mathematics and science.

--On a per capita basis, for each engineer produced yearly in the U.S., the United Kingdom produces 1.1, West Germany 1.4, Japan 2.6, and the Soviet Union 4.1 engineers.

Thus student achievement and participation in mathematics and science are decreasing while jobs and society are becoming more and more scientifically and technically oriented.

The NSB Commission includes representatives from state and local governments, business and industry, precollege and higher education, professional societies and foundations, and military, the media and the law. We see strength in our diversity and we hope our "grass roots" will be reflected in our report, to be issues early this fall.

The Commission has been charged to define a national agenda for improving math and science education and is expected to spell out what different sectors such as government, educators, and industry can do. We all, I daresay, feel a lot humbler about the task than we did at our first meeting last July, but we're still hard at work.

At that first meeting we agreed on what we see as the details of the problem, which are contained in our first report, Today's Problems Tomorrow's Crises. The underlying cause of the math and science problem, we think, is a lack of broad public awareness of the need for math, science and technology education for all students. We think such an education is essential for everyone--not just scientists and engineers, not just technicians, but everyone-- if they are to live and work in the society of the future.

Commission Organization and Activities

The Commission has been looking at the teaching profession, the curriculum, and the question of equipment, especially the new technologies such as computers.

We are also concerned about access in its broadest sense--access to high quality math and science for rural and central city, women, minority, physically handicapped, and economically disadvantaged students. And we are concerned about public perception and how you change it in a constructive and lasting way.

To carry out our work, we have formed four Task Groups, each focusing on a sector involved in the problem. One is looking at educators, such as teachers and school administrators. Another is looking at groups such as professional associations, foundations, and the media. A third is looking at those who receive or employ students coming out of high school--business, the military and, of course, higher education. A fourth Task Group, which I chair, is focusing on the role of Federal, state and local government, including local school boards.

Each group has added 3-5 additional members to broaden its expertise. The Task Group on Governments added the Governor of Arizona, the President of the California State Board of Education, a State Senator from Florida, the President of the Rhode Island School Board Association, and the President of the Columbia, Missouri School Board. We have made a number of site visits, participated in conferences and workshops, and met with groups with interests in precollege education. The activities of the Task Groups and the Commission as a whole are summarized in our January interim report to the National Science Board.

What have we found so far?

The Teaching Profession

The report of the Florida Governor's Commission, issued in January, states, "The big issue in the '80s will be how to attract, educate, and sustain high quality teachers." Our findings certainly support this.

--In 1981, almost all states reported shortages of adequate math, physics, and chemistry teachers.

--Half of the teachers hired nationwide in 1981 to teach math and science were uncertified.

--Forty percent of the math teachers, grades 7-12, in North Carolina during 1980-82 have no math certification.

--Fewer than one-third of our high schools offer physics courses taught by qualified physics teachers.

--The Soviet Union graduates more new physics teachers each year (8,300) than the total number of physics teachers in the U.S. (6,700).

--Between 1971 and 1980, student teachers in math declined fourfold, in science threefold, and only half of these student teachers have been entering the teaching professions.

--25 percent of those currently teaching math and science plan to leave in the next two years.

--Four-fifths of the math and science teachers in one survey had not had even a ten-hour workshop in over ten years.

--Universities in 7 southern states reported turnign out 7,000 PE majors and 400 math majors in a recent year.

It is clear that we need to recognize teaching--investing in human capital--as the significant profession that it is. The low status we ascribe to teaching is reflected in the salary differentials with industry, in the absence of full-year employment and the necessity of finding a part-time summer job, most of all in the inability of the profession to attract high quality students in sufficient numbers. Recent studies of college admissions tests indicate that education majors have much weaker academic skills than students majoring in other fields.

Of perhaps greater concern for the long term are the changing attitudes of college freshmen. The 22 percent of entering freshmen who aspired to teaching careers in 1966 have now become 4.7 percent. Meanwhile, the percent interested in business as a career has grown steadily from 11.6 percent to 20.2 percent. The objective of being financially well-off has also grown steadily in importance. So there are some fundamental values here that may have to change before education regains the high priority it had in the eyes of this nation's Founding Fathers.

There are some important steps that we can begin to take now, including:

--For the long-term, we need, especially at the state level, a careful review of salary levels, promotion procedures, and tenure provisions, to find ways to bring salaries and other incentives more in line with the private sector and to recognize outstanding effort and performance. Many states are already beginning to look at this problem.

--In the immediate future we need to increase opportunities for in-place teachers to upgrade their skills, preferably through summer and inservice programs involving college and university and perhaps industry scientists. This would make much better use of time now spent in low-paying jobs to make ends meet. Federal leadership and suppost can make a big difference, but states can also help and so can local school boards in placing a high priority on this.

--States must, and are beginning to, raise the certification requirements for math and science teachers, even though this may make the shortage worse in the near term. Teachers of high school math, for example, should be undergraduate majors in that subject from an institution with acceptable standards, or should pass a stiff examination. State Boards of Education should not relax certification standards once they are in place, thereby canceling their effect. North Carolina has recommended that after 1985-86 all science and math teachers be appropriately qualified in their fields.

--Institutions of higher education have a crucial role to play in motivating and training precollege math and science teachers and helping them to keep up-to-date in their fields. Unfortunately, students don't get much encouragement to go into teaching. As my fellow commissioner, Pat Graham, Dean of the School of Education at Harvard, said recently, "Until those of us in the university consider teaching and administrating in elementary and secondary schools as important and as challenging as the other fields which we assist our students and graduates to enter and pursue, we will be bereft of talent in those vital institutions, and we will have ourselves to blame."

--Institutions of higher education are beginning to reexamine their teacher training programs to try to ensure that they are challenging to good students and that students are well-trained in their particular subject matter. President William Friday of the University of North Carolina System is a member of Governor Hunt's Task Force. Recently he announced that, starting this fall, it will be as difficult to get into the University's School of Education as into medicine or law. It will become a post-graduate program. Other universities are moving in this direction also.

--Institutions of higher education can play a significant role in working with teachers and administrators at the precollege level, through institutes and other workshops, to help in teaching particular curricula, to upgrade skills, and to keep in continuing touch with the schools about what they need and what the colleges and universities can offer. Support for such programs needs to be found and the Federal Government may have to take the lead.

--Recognition of good teaching by states and the Federal government, by institutions of higher education (for example, Harvard awards an honorary degree every year to an outstanding teacher) and by professional societies and private foundations can help.

--Incentives for students to enter math and science teaching, such as forgivable loans, will not be effective in the long run if the status of the profession does not change. It will just lower the price tag for that person to get training in math or science, but they will soon leave for greener fields.

Upgrading the status of teaching will not be easy, however, especially as long as higher education considers its main mission to be research and the reward system is geared to that. It is time we woke up to the tremendous importance for the nation of how well we prepare our students.

Curriculum

In the curriculum area, we are concerned that science at the elementary level received so little attention and that teachers at that level are not equipped to arouse the curiousity and sustain the interest of children, just when it is most crucial to do so. At the secondary level we are puzzled as to how students can be pursuaded to commit themselves to the hard courses, to make the effort at mastery that seems lacking in many classrooms.

Part of this is related to the fact that science curricula have not been updated for a number of years and do not have meaning in terms of examples from everyday life. In addition, many students do not seem to be learning problem-solving skills --what some have called "learning to learn" skills that involve reasoning, conceptualizing, and analyzing. The business community has indicated dismay about this also.

Part of the problem is that even in cases where curricula are available, course requirements are so minimal today and the opportunity to take easy electives so great that students often won't take these so-called difficult courses. Furthermore, the shortage of teachers qualified to teach them and the absence of opportunities for most teachers to upgrade their substantive knowledge undoubtedly turns students off. Finally, many students are simply counseled out of taking these courses, which is distressing.

We have begun a process that we hope others will take over and develop further. We believe it important to the ultimate success of any efforts to improve precollege education that we know in a systematic way what it is we want students to know or be able to do when they finish high school.

Therefore, we have commissioned some workshops and studies directed explicitly toward that question--for mathematics, for science, and for technology. We don't expect complete answers to such a complex question by the end of the Commission's

short life. But we plan to distribute the results of these studies widely with the hope of stimulating others to answering the important question of what exactly it is we are directing our educational efforts toward. I believe we are the only group that is engaging in such a comprehensive and detailed look at the curriculum. The Commission's recommendations may include suggestions of how this process might proceed and who should provide the necessary leadership.

The Conference Board of the Mathematical Sciences has reported to the Commission on what should be fundamental in the K-12 mathematics curriculum. Similar reports are being prepared by the American Chemical Society, NSF Engineering Advisory Committee (with respect to technology), the Federation of Behavioral, Psychological, and Cognitive Sciences, and other professional groups. There is strong support on the Commission for renewed support from NSF related to curriculum development to ensure the continuation of this process.

We are also looking at how to ensure that students are exposed to these fundamentals and are motivated to learn them, as well as how to fill up the pool and plug the drain of high quality teachers trained to teach these courses. We believe we are not expecting nearly enough of our students, and this is part of the problem.

--Only one-third of the nation's 16,500 school districts require more than one year of math and science.

--One-third of our high schools do not offer enough math to qualify their graduates for engineering schools.

--Fewer that one-third of our high schools offer physics courses taught by qualified physics teachers.

--Our school year in the U.S. averages 180 days.

By contrast:

--In Japan, 3 science and 4 mathematics courses are customary at the high school level. And the school year averages 240 days.

--The Soviet Union has the heaviest focus of all on math and science. Every youngster is required to complete 5 years of physics, 4 of chemistry, 4 of biology, 5 of algebra, and 2 of calculus. Five million high school students are taking calculus, while the corresponding U.S. figure is about 100,000.

It is clear that the amount of time spent in school each day, week, and year is less in the U.S. than in other countries such as Japan, West Germany, and Russia. In addition, the proportion of the time spent on science and math is less in our schools. One alternative that a number of states are considering and some have already enacted, is increasing the amount of time spent in school. We also think

it important that states and local school systems establish priorities and take out of the curriculum those many nonessential courses that have proliferated over the last decade. A high school in Illinois, for example, listed 252 courses in its 65-page Curriculum Bulletin.

Many states are acting to raise high school graduation requirements and to extend competency testing of teachers and students. Underlying this whole question of what students should know is the matter of higher expectations. Before we can expect more, we really need to know more clearly where we are now. This will require a clearer set of goals for the nation than we now have--a concensus on where we ought to be and want to be five years from now, for example. And we need a clearer picture of exactly where we are not and better means of assessing performance to determine whether we are achieving our goals. Otherwise, we are just going to go on fooling ourselves. The public needs to know, and has a right to know, about the real status of student achievement.

Tools and Technologies

The third area of focus is that of tools and technologies and the relationship between technology and education. There is a need to incorporate courses about technology, about how to use computers, videodiscs and telecommunications into our curricula. Technology can also plan an important role in the educational process.

Computers offer the potential of greater efficiency in learning, through personalized and independent study, which might also help alleviate the teacher shortage to some extent. They have the capacity of reaching large populations and helping to ensure more equality of access to education for rural and underprivileged students. At the same time, their use could encourage familiarity with one of the most powerufl tools of our society. There are strong arguments that every student and every teacher should be familiar with computer operations, as this technology continues its rapid invasion of our society. The issue of access becomes very clear here. There is danger that the new technologies will widen the gap between more and less advantaged students and there are signs that this is already happening.

The numbers of computers in schools is already doubling each year and is expected to be over one and a half million by 1988. The cost of computers and videodiscs is dropping rapidly, and parents are eager to have their children learn their use. We are pursuaded that school activities can be a positive factor in precollege math, science, and technology education. The major questions are how to ensure access and effective use of these tools in the schools.

It has been suggested that computers be introduced as rapidly as possible into all math and science classes and that all math and science teachers be trained in the use of computers and educational technology. Tax incentives for industry contributions of computers to school systems are under consideration in Congress. A number of states are already taking steps to make computer literacy a requirement for state certification of future teachers and for high school graduation.

An important area is that of software development. Certainly it is crucial that quality standards be high in this aspect of computer implementation. Many teachers are complaining about the quality of software that is being produced by private companies. California has recommended regional Teacher Education and Computer Centers with one center serving as a statewide clearinghouse for software evaluation. This may also be an area where the National Science Foundation's involvement and support could establish some quality standards.

Conclusion

Much is happening in education today. It is possible that we are approaching an important crossroads or turning point. The idea of national goals and strategies is not new to our educational system, but in the past it has focused on quite specific areas--needed job skills in vocational education, more scientists and engineers under NDEA, or greater equality or opportunity under Title I. Now we are beginning to hear reference to goals in a more comprehensive sense--goals for all teachers and all students.

Our survival as a nation may require that we begin to think in these terms. If we are to do it and still retain the valuable diversity and pluralism of our system, which have always been its strength, it will require the combined efforts and ingenuity of everyone including, above all, parents. It will also require a commitment to and by all students. Every student must be equipped, to the greatest extent possible, with the understanding and the skills that will enable her or him to participate fully in the world of tomorrow. That is the challenge.

THE SCIENCE EDUCATION DEBATE IN CONGRESS

Douglas Norell
Senior Legislative Assistant
for Rep. Byron Dorgan

When I first looked at the report of the National Commission on Educational Excellence I thought that I was reading the Pentagon's annual report on military posture.

For one thing, "A Nation At Risk" sounded like military jargon. For another, the opening statement of the report also trumpeted a martial air:

". . . The educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people."

"If an unfriendly foreign power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war."

And so the report begins, right down to the charge that "we have, in effect, been committing an act of unthinking, unilateral educational disarmament." This is heady stuff indeed. It will certainly win some friends in Congress where military metaphors resound in the chambers each day.

But is there a crisis? The test of the scientific method is to assume not, unless compelling evidence suggests otherwise. Let's take a brief look at the evidence which forms the background for the debate in Congress on science education.

The Crisis in Doubt?

Crisis usually refers to the "decisive state of things." In medicine, for example, it may mean the period that determines the life or death of the patient. In politics, it conjures the memory of an event like the "Cuban Missile Crisis"--a time when the very survival of our nation did hang in the balance.

Is our educational system--and science education in particular--so bleak that our nation is up for grabs? This seems overdrawn. After all, millions of students pour into science classrooms to learn the application of scientific method and to master several scientific and mathematical disciplines.

There is even some good news. A National Assessment survey recently showed that minority students have made strides in math skills. Students overall have made progress in basic arithmetic, after a decline in basic skills in the 1970's.

From an international view, America must look quite strong in math and science as well. Look at the thousands of foreign students who flock to the United States to study math, science, and engineering. In 1981, in fact, nearly 50% of our engineering degrees went to foreign doctoral students.

On the Ropes or in the Ring?

Looked at in the wider context of our economic and military performance we can also see some bright spots. It's not that clear that America has lost its technological edge, for example. Note that economist Robert J. Samuelson calls the drive for a new industrial policy "high-tech hysteria."

Samuelson points out, that despite the moans about our economic doldrums, the U.S. should not be mistaken for a second-rate technological power. Commerce Department statistics show that the U.S. share of high technology exports--electronics, aircraft, chemicals, and sophisticated machines--held steady at 24% in 1980 as in 1972. Meanwhile Japan's share rose slightly from 10% to 12%, while the German share dropped from 18.3 to 17.5%. And let's not forget agriculture.

What is new is that the U.S. is facing some fierce competition. Perhaps we should say that the U.S. is not so much on the ropes, as in the ring, for the first time since World War II.

The same might be said of our military position. From 1945 to about 1965 the U.S. remained the unrivaled superpower of the post-war world. Gradually, the Soviet Union recovered from the devastation of World War II, imitated many of our military advances, and finally pulled up along side of us in some categories of military strength.

By 1982 the Pentagon concluded that the U.S. and U.S.S.R. had roughly equal military power. Yet today, we often hear that our troops can't read, our missiles are outdated, and the Russians are coming.

Make no mistake, Soviet power is formidable and growing. But on balance, the U.S. still retains with its NATO allies the kind of military strength to prevent Soviet adventurism. In some cases, as with our sea-based Trident missiles, we have a superior capacity.

Yet, in Congress, the assumption that we have either lost or are about to lose our economic or military edge is one of the driving forces for upgrading science and math education. And Congress is not without reasons to press for an enlarged federal role in scientific education.

The Blue Bomb

I have affectionately dubbed the Education Commission's report "the blue bomb," for reasons cited before. Let's take another look at the explosive power of the report--as it pertains to science education.

* 13% of all 17-year-olds are functionally illiterate
* average math scores on SAT tests dropped 40 points from 1963 to 1980
* business and military leaders complain because they must spend millions of dollars in remedial training in reading and computation.

Surely these signs point to a crisis in science education.

And there is more bad news at the college level. In general we face a sharp decline in professors with doctorates in scientific fields and deterioration of laboratory equipment. In 1980, 10% of the engineering faculty positions remained vacant. Not surprisingly, we have also seen a 10% decline in engineering Ph.D.'s over 10 years.

Internationally, we find that German and Japanese students spend far more time and take much more math and science than our American counterparts. Some studies suggest that the Soviets produce five times the engineers we do and while the Japanese equal or exceed us on that same score with one-half the population.

So, crisis or not, there is enough bad news on science education to have created a serious debate in Congress. What is Congress doing about the problem?

The Debate in Congress

The debate is not strictly a repeat of the panic response to the Soviet launching of the Sputnik satellite in 1957. President Reagan has not responded with the same intensity as President Eisenhower and neither has the Congress.

Then, the issue was drawn very sharply: the Russians are coming. Today, it's not only the Russians, but the Japanese and Germans as well. Because the stakes are not just military, but economic as well, it has taken Congress some time to define problems and responses.

But like the post-Sputnik era, Congress is beginning to feel constituent pressure to do something fast. Since President Reagan has at least recognized a problem and proposed a $75 million package for science education, it seems safe for conservatives and liberals alike to join the battle for better science education.

To date, the House has passed a $425 million package of federal science and math education programs. This includes $250 million in direct grants to the states, $75 million for teaching scholarships and summer institutes, and $100 million for

training of technical and scientific personnel. House bill H.R. 1310 divides up about $300 million to the Department of Education and $125 million to the National Science Foundation. Looked at another way, it provides $250 million for elementary and secondary science education, $75 million for postsecondary purposes, and the remaining $100 million for science policy.

Even though the House had to get both the Education and Labor Committee and the Science and Technology Committee to get their heads together, the Senate has not yet acted--despite the fact that only one Senate panel has jurisdiction.

Perhaps the Senate Labor and Human Resources Committee had to wade through an ocean of some 15 science education bills. An alternative reason for delay is that the Committee is working carefully to craft a consensus bill that will win on the floor.

In any case, the education subcommittee of the full Senate committee has reported a science education bill (S. 530). The full committee is slated to mark up this bill on May 4. From conversations with key staff people in both the House and Senate, it looks like the Senate bill may include:

* a total price tag of about $500 million
* $400 million for Department of Education programs for elementary and secondary education
* $100 million for postsecondary science under NSF.

Assuming the Senate eventually passed a bill like this, the House and Senate would have to have conferences to work out a compromise measure. Some of the issues that might be at stake in such a conference include:

1. what will be the distribution formula for grants to states? Or the role of federal and state governments?
2. will the Secretary of Education retain a discretionary fund? Will state agencies?
3. will each state be insured a minimum amount of funds under each program?
4. how narrowly will funds be targeted?
5. will special science education programs continue beyond the next few years?
6. will scholarships benefit existing or future teachers?
7. what mix between NSF and Department roles will be reached?
8. will the White House science advisor have a major role?

Meanwhile, Congress probably won't address some other issues at all. For example, the Members may not tackle the issue of differential salaries for certain

teachers. There will be scant debate on why test scores have declined or how science education problems fit into a larger social and educational context. Science and values will get less than headline attention.

What does seem clear is that Congress will move to increase the federal role in improving math and science education. The public is concerned, so Congress is concerned. Congress sees an important, if ill-defined, connection between our economic and military problems and our science education pitfalls.

What I have described is only part of the process for funding federal science education programs. The prior discussion pertains only to the authorization process that establishes federal programs by law and sets limits on the amount that Congress can appropriate for them.

Congress then must pass an appropriation bill to determine how much money NSF and the Department of Education can actually spend on each authorized program.

And another question mark, of course, is what the President may do with either science education authorizations or appropriations. The Administration has advanced a much more modest $75 million program. Furthermore, the report of its Commission on Education Excellence did not recommend a major federal role for tackling educational problems. If the President feels great pressure from Congress and the public, he might swallow hard and sign the bills in question. If not, a veto might occur.

That prospect brings the debate in Congress back full circle to the scientific community. If science teachers and professors feel deeply about the need for an expanded federal role in science education, they will have to decide what role they should play in bringing this about.

It's a tough issue for science educators because of their traditional reluctance to interject themselves in the political process. But it will be equally hard for Congress and the President to support expensive, and maybe risky, measures if they do not perceive that the nation's science educators strongly favor the efforts.

Nor should the science community hesitate to raise tough questions about any federal science education initiatives. Will the investments pay off? Will these measures do anything to improve the quality of science education? Will science teachers and professors have a meaningful role to play in planning and implementing the programs?

Congress seems ready to move on science education. The question I leave with you is how will you influence the pace, direction, and scope of that movement?

Addendum

On May 16, 1983, S. 1285 was introduced in the Senate. This bill was termed the Education for Economic Security Act and incorporated parts of several other bills, including S. 530. As of April, 1984, S. 1285 is awaiting final action in the Senate. No omnibus science education bill has been passed by Congress.

SCIENCE CURRICULUM: FROM SPUTNIK TO THE TOYOTA

Vito Perrone, Dean
Center for Teaching and Learning
University of North Dakota

Being principally a historian, and finding as I do that historical perspective is generally neglected in discussions of contemporary issues, I feel compelled to make--before I get to science education directly--some general remarks about schooling in the United States. My hope is that these historical remarks will be useful for the context they provide, though I must admit their rather indirect, possibly abstruse, nature in relation to the symposium as a whole.

America's commitments to its elementary and secondary schools have for much of the past 100 years had something of a boom-bust quality. Fiscal support has been uneven as have expectations. Schools were once expected to provide rudimentary skills of reading, writing, and numbers to the majority and high level skills and knowledge to the few. For the former who went beyond the elementary school, vocational training was added in 1900; for the latter, who coincidently came principally from the middle and upper classes, were white, and were not of recent immigrant status, the basic liberal arts oriented curriculum expanded at the turn of the century to take into account the rapid advances in science and technology. There was in 1900 a growing and more potent rhetoric about universalism and equality of opportunity but the practice did not yet correspond.

By 1940, universalism was well on the road to realization for whites in America --the majority were completing high school programs by this time. But the high schools were also different in 1940 than they had been in 1900. They were more comprehensive--there were fewer requirements in what were once core academic courses. Foreign language, for example, peaked in 1916 and declined each year from that point on. A high school education began to be something different for different students. Expectations for the schools--as universalism became increasingly the practice--also expanded. (There is a great deal of talk today about the expansion of courses and programs in the 60's--we hear, for example, a great deal about proliferation--but the expansion in the 20's was significantly larger.) Schools by the 30's and 40's were becoming--in addition to their usual fare--centers for personal counseling, nutrition education, moral development, consumer training, and the like.

In the 1950's, universalism conceptually finally began to take into account minority populations. The numbers of young people staying in high school to graduation began to escalate more rapidly than in any period of time in our history. From the 50% of the total age cohort completing high school in 1950, the percentage rose by 1967 to 76%, a figure considered remarkable by many at that time. It was reached in part by a continuing differentiation of standards and expectations along with the acceptance of an increasing array of social obligations by the schools --drug and alcohol counseling, safety and driver education, family planning education, career exploration, job placement programs, breakfast programs, etc. In the 1970's and 80's--though the percentage of students completing high school has declined from the 1967 peak--there is a great deal of talk about needing to redress the equity-quality balance in favor of quality, essentially a belief that we have somehow paid a price for so much attention to universalism or equity. That, as you must know, is not a particularly uplifting or refreshing pattern of discourse. We need without question to concentrate our energies and resources on both equity and quality. We can't be satisfied with our level of universalism because it isn't adequate--it has already fallen behind France, West Germany, the Soviet Union, and Japan--and we clearly can't be satisfied with the differentiation of quailty for those who persevere in the system. At the upper levels, our students receive an education equal to the best in any country--but at the lower levels, it is far poorer than a modern technologically oriented society ought to accept. Not all of those Soviet 17-18 year olds in Calculus succeed in the fullest sense of what is meant by the word "succeed"--but they do clearly gain from the experience and the surrounding commitments to support them at the level of their understanding. They aren't sent off to do elementary arithmetic. This isn't a plea for universal calculus study in American schools--it does suggest, however, some rethinking of the kinds of alternatives we have tended to encourage for those seen as a bit less able academically. The kind of tracking we now do isn't constructive.

Though the recent report of the National Commission on Excellence doesn't express the point very well, I believe we need today more than ever a coherent statement of purposes and expectations for schools buttressed by the will to support the related implications. We are currently in a cultural period in which education is not high on the agenda and it may be worse, not better, in the future in spite of the kinds of legislation being proposed. Having said all of that, I'll come closer to the topic at hand.

Science education in the schools has become once again, as it was after October 1957 when the Soviet Union put their silver ball into orbit, a topic of widespread popular discussion. In 1957, there was concern that America's technological superiority might be in jeopardy if math and science teaching did not get closer to the post World War II advances in scientific knowledge, especially with regard to the physical sciences, and if interest in math and science did not enlarge. The drive for reform was led by University scholars supported by a healthy infusion of federal dollars. I have had opportunities to interact personally with, or have heard, many of the giants of the reform--Joseph Schwab, Thomas Eisner, and Charles Walcott in Biology; Jerrold Zaccharias and Philip Morison in Physics; David Hawkins and George Hein in Elementary Science; Bill Hull and David Page in Mathematics; and Jerome Bruner in Psychology, among others. They, and their colleagues, principally from MIT, Harvard, Cornell, Chicago, Illinois, Berkeley, and Stanford, produced wonderful materials and spoke eloquently for the need to encourage a scientific mode of thought. Math and science were not conceived by these reformers as being organized around immutable facts of laws, as linear subject matters. Inquiry as a model of discourse was reaffirmed--questioning, skepticism, developing hypotheses, experimentation, examining a range of information, confirming and disconfirming, arriving at possible explanations. An openendedness characterized the discussion. Materials and ideas growing out of careful observation over time became the critical ingredients. There was talk of the need to "uncover a subject" rather than "cover a subject." A great deal was made out of the distinction.

I quote from an introduction to the Elementary Science Study--one of the most imaginative of all the science curriculum reform efforts--a model of what science at its best ought to be about.

> "It is apparent that children are scientists by disposition: They ask questions and use their senses as well as their reasoning powers to explore their physical environments; they derive great satisfaction from finding out what makes things tick; they like solving problems; they are challenged by new materials or by new ways of using familiar materials. It is this natural curiosity of children and their freedom from preconceptions of difficulty that ESS tries to cultivate and direct into deeper channels. It is our intention to enrich every child's understandings . . . we want children to be at home with modern technology, not be intimidated by it. We have tried to incorporate both the spirit and the substance of science into our program in such a way that the child's own rich world of exploration becomes more disciplined, more manageable and more satisfying."

In regard to teaching strategy, the ESS guide relates:

> "In the course of developing our units we have found it worthwhile to abandon a great many conventional ideas about teaching. We want students not only to recongize scientific authority but also to develop both the confidence and the skills to question it intelligently. For this reason we feel it is necessary for the student to confront the real world and its physical materials directly, rather than through intermediates such as textbooks."

And further: "We caution teachers against explaining things prematurely and against overdirecting student exploration." Are the values inherent in the foregoing ESS materials--skepticism, questioning, challenging, openness, alternative possibilities--the values which permeate the schools? or the society as a whole? The schools have always been mirrors of the society. How could they be otherwise? I will come back to this point more potently.

The teacher training institutes which flowered and which indeed provided for many teachers a revitalization, a significant increase in math and science knowledge and understanding, a fresh, even a liberating, way of thinking about teaching, insured that some of the reform would find its way into the schools. But by 1967 the reform boom had already begun to wane. Stung by a strong political backlash with MACOS, an imaginative course of study with strong evolutionary overtones, NSF Curriculum efforts ended.

Two years ago I listened with great fascination to Peter Dow, who directed the MACOS project, describe his first public hearing on the content of the program, organized by a congressional delegation in Arizona. He presented, as he said, "in the best academic form possible," the theory which guided the development of the program, rationales for the particular selections of topics and materials, summaries of the scholarship upon which the content was based, and the like, only to be asked by a person holding up his hand--"Dr. Dow, is this a hand or a fin?" Peter Dow suggested he didn't understand the questions's connection to MACOS or his presentation. But the question was repeated--not only there but in public hearing after public hearing. He ultimately came to understand the question too well! One could argue that the entire NSF curriculum development effort should not have been forced to bear the burden of the public controversy surrounding MACOS but NSF learned as did others in education that public policy can take many contradictory directions, can be influenced by the most improbable events.

The NSF commissioned study conducted by Robert Stake during 1975-77 confirmed what observers had already noted--that few remnants of the science reform movement existed. Fewer than 10% of American students were using materials spawned in

that period. Inquiry oriented programs existed in such schools as the Bronx School of Science and in the best private schools but were virtually absent in most public school settings. The curriculum materials were in storage or had been discarded. Textbooks and workbooks, the bane that the scientists found in 1957, had become again the practice. And in relation to the textbooks, the threat of censorship had become more potent than ever. We have come, in many respects, to see Scopes revisited.

What went wrong? What ought we to think about as we prepare for what may --though I am skeptical--become a new interest in math and science education?

When Joseph Schwab was asked this question, he stated that the reform efforts didn't involve soon enough the thoughtful teachers that existed, persons who could have helped guide the process in more realistic directions.* He also noted the fact that funding dropped off at the most critical juncture--when the important revisions needed attention.

What the reformers sought, it appears, was counter to the experiences of many of those responsible for governing and administering schools. It was also counter to the experience of many of the parents who had children in schools. What the reform efforts called for demanded more time and energy--the higher level of intensity that inquiry oriented teaching demands. They found that school schedules were difficult to modify. At the secondary school level they considered a teaching load of 3-4 hours a day with 75-100 students maximum. To expect more, Morison, Zaccharias, and Hawkins noted, was to assure that teaching practice would return to textbooks and workbooks and didactic instruction--inquiry would not likely be sustained. But the loads continued to be 150-175 students and 5-6 hours per day of teaching. The conditions of teaching were not then particularly favorable and they remain problematic today.

Jerrold Zaccharias spoke of the lingering power of "testing mechanisms" and "covering material" as being too powerful--always in the way, pulling teachers back to textbooks and workbooks, and away from science as scientists understand and

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*Unfortunately, we have very little careful description of the excellent practice that existed in the schools during the period when math and science reform was on the public's mind. We don't have, as a result, much information on the conditions which contributed to successful practice, the kinds of questions raised by teachers and students in the process of successful practice, the reflections of teachers about their classroom efforts, the materials, etc.

practice it. Bill Hull noted that math and science need skepticism as its most desired response but acknowledged recently that skepticism was not desired in the schools or in the society. Rather than the exploration of alternative possibilities, certainty, he believed, was the preferred outcome.

In this retrospective vein, I commend to you an essay by David Hawkins prepared for the Division of Research and Development of NSF in 1977 entitled "Critical Barriers to Science Learning." Rather than affirming that the schools and the society are imbedded deeply with attitudes antithetical to science at its best, Hawkins suggests that those who sought reform "failed to extend that very spirit of investigation [they were encouraging] far enough to become radically troubled about the dimensions of the task at hand." In this regard he noted John Dewey's telling comment that science is in need of a reconstruction aimed at "increasing its permeability by the common understanding--the design of a working ambience for students which initiates them to begin to practice the ways of thought which science has evolved." Hawkins describes in the essay the elementary scientific understandings that were centuries in the making but remain counter to casual observations, don't get put aside by the provision of counter information, and are "critical barriers" to productive science learning. He notes in this regard issues of "size and scale," an example of which I'll share a bit later. But before I do, let me first share another example which he uses because it appeared in a different vein in a research that I read only yesterday--where Michigan State University researchers found that a significant percentage of elementary and junior high students didn't believe that plant grew from the outside in even though their texts said this was so.

Hawkins comments on this as follows:

> "Another aspect of this topic concerns the elements of biochemistry and their relation to the green cover of the globe. For thousands of years farmers have farmed well in the belief that their crops are earth-earthy, pushing up from the maternal soil and somehow composed of it. Water and the heat of the sun were necessary but the stuff of life came from below. That view, like some Jungian ancestral memory, still dominates the thought processes of most of us. It is only a few generations since there was a scientific realization that trees are essentially shaped from air and water, that sunlight drives their circulatory systems, that they grow from the outside in. A large majority of our adult students will tend to believe the opposite: that plants--grasses or trees--push up out of the ground, their blades or branches slowly rising, their newest growth in the center, and all this despite a forgotten course in biology."

I'll come back now to the "size and scale" issue by sharing an account writtten by Maja Apelman, a master teacher and teacher-educator who worked with David Hawkins for two weeks on "the effects of size and scale."

> "I know how exciting and comforting--and rare--it is to have one's commonsense view of the world attended to and respected by a scientist. I also know how perturbing and confusing--and satisfying--it can be to realize that there is a different way of perceiving, thinking about, and understanding the world. . . .
>
> One afternoon a group of teachers and I went outside to try to estimate the leaf area of a large maple tree by using the tree's shadow. We never got past measuring the shadow. Here we were, five teachers and an advisor, all totally absorbed for a good hour trying to calculate its area.
>
> First we measured the length and width of the shadow, approximately twenty-five by forty feet. Then we multiplied these two figures--we all remembered that lesson from school. The result was one thousand square feet. Nobody would believe that; it sounded far too big for what we saw. We remeasured and recalculated and got the same figure. J. said she wished there was a ruler that would measure square feet. We tried to invent one: for each foot in length a corresponding square area would flip out--one linear foot, one square foot, two linear feet, four square feet, etc. Since we didn't have such a ruler we improvised. I had a pad of 8½ by 11 paper, and we figured that each sheet could represent a square foot if we left some space between the sheets. (There was no problem going from one linear foot to one square foot.) We started to cover the shadow area with our yellow sheets. We soon realized that we might well need a thousand sheets to cover the whole shadow area. We were amazed. Then J. remembered buying carpeting for her two bedrooms. She was sure that her bedrooms were at least as large as the shadow area of the tree but she was also sure that she didn't order a thousand square feet of carpeting. "What are the dimensions of one bedroom?" we asked her. She didn't know. "How much furniture is in your bedroom?" we continued. "A double bed"--two of us promptly lay down on the grass--"and a chest of drawers"--another class member lay down to represent the chest. Now J. realized how small her bedroom really was compared to the maple tree's shadow.
>
> We all marvelled at our lack of experience with square feet. Our intuition was completely wrong yet we were so sure we were right that we refused to believe the figures we calculated until we had built up a good part of the thousand square feet one square foot at a time! Later on I tried to analyze our difficulty. We were all comfortable with linear measurements and could probably have estimated the length and width of the shadow fairly accurately. But when we multiplied twenty-five by forty (as we had been taught to do to get area--the sort of thing that is rarely questioned when you first learn it in school) we got a very large figure: one thousand. One thousand what? Again we did what we had been taught and tacked on "square feet." But our minds were still on linear dimensions and we could not see how an area <u>enclosed</u> (even that word may connote smallness) by twenty-five and forty feet respectively

> could suddenly measure one thousand. That number seemed far too big since we had so little experience switching from linear to area dimensions."

I realize that I tood a good deal of time with this point but I agree with Hawkins that reform is more than more courses and more information. We need to provide much more experience with science and that takes a lot of time and considerable teacher understanding.

If in 1957 there was a fear that American technological superiority might be in jeopardy, in 1983, in the Year of the Toyota, there is a belief and a good deal of corroborating evidence that American technological superiority no longer exists. There is, in contrast to 1957, however, another fact educationally. The teaching profession is in the midst of a decline in quality and spirit. Over 50% of America's teachers have indicated in surveys that if they could do it over, they wouldn't consider teaching. Many came to the schools because they believed in the ideas expressed in the 60's science reform, but feel now that such beliefs are not valued. They came to teach chemistry but found that much of their day was spent with general science or they were asked, because they had had twelve hours of biology and twelve hours of physics, to teach those courses as well. They found also that they had little to do with the selection of instructional materials.

The numbers of well prepared science and math teachers have declined; not enough are being prepared nationally to fill the positions being left vacant by retirements and departures for fields outside education. The bills aimed at encouraging more individuals to pursue science teaching careers and incentives for business and industry to give some of their employees time to teach part-time in the schools are worthwhile. The need for higher salaries is also long overdue though I must add that higher salaries are necessary for all teachers, not just those in math and science. Reports which are encouraging states and local school districts to enlarge high school requirements in math and science are likewise useful.

But problems still exist! They relate in large measure to the kinds of issues which emerged in the early post Sputnik period. But there are also others. What is to be taught? Is our concern the understanding of "size and scale" (one of the critical barriers Hawkins notes in the essay I recommended to you), helping children and young people develop their own systems for solving problems,

or it is arithmetic facts--basic skills instruction? It isn't the ability to multiply and add that students struggle with today--the standardized test data make this fairly clear. It is in the application of mathematics for solving complex problems that they falter. Filling workbook after workbook has clearly not produced understanding, or application, or interest. Indeed, interest in math and science is lower today than in 1957.

How will the scientists reenter this arena of education after their earlier and not particularly successful experience? To talk of making science and math more prominent, to extend it, to bring inquiry back is to support fairly broad reform. It is much more than increasing the numbers of math and science teachers or increasing math and science requirements in the schools. Reform needs to touch the curriculum far beyond math and science. If inquiry, skepticism, openendedness are not part of the curriculum in history and English, for example, they won't in the long run survive in math and science programs either. This, among other things, was learned earlier. Unfortunately, this broad view is not yet a part of the contemporary discourse.

In regard to teachers, I need to say that I am concerned about getting into schools our best and brightest--even if they remain for only a few years. My experience is, however, that math and science faculties have tended for a long time not to recommend that their best and brightest, most promising students, consider teaching. Until they do, there are likely to remain limitations in what is possible.

One last remark about science and math teaching needs to be made. In the midst of the previous science reform era, the Nobel Prize winning physicist I. Rabi suggested that science teaching at the university level was hardly a model of excellence. He described most freshman-sophomore level courses as cookbook oriented, anithetical to scientific practice and thought, contributing to a lack of interest in science among students. Schwab had a similar view, noting that science teaching at the university level tended to remain--in spite of the reform being fostered in elementary and secondary schools--didactic, linear, not particularly exploratory or problematic, nonconsonant with the most promising theory and practice. Is it different today? I don't believe so!

We need more attention on math and science in the schools and in our colleges and universities. But to really make a difference qualitatively in the outcomes, we need a fiscal and moral investment far greater than we have made in a long time. We need more continuity of effort from college-university faculty over a long time. I remain unconvinced that we have very many people willing to make the necessary long-term commitments.

We have today begun to recapture public interest but reform is more than rhetoric. I believe we have to begin again but we also ought to know we have traveled some of the paths before, we know some of the difficulties. As a consequence, we should prepare ourselves for growth that may not move the mountains as quickly as we would like. Nonetheless, better to chip away than do nothing.

SCIENCE EDUCATION: TRENDS IN NORTH DAKOTA

Donald R. Scoby
Professor of Botany/Biology
North Dakota State University

What I want to discuss is some of the trends in science education, and what has happened in North Dakota. I will also discuss the science methods class - what type of instruction is involved in that, what we try to do. Also, I will give some recommendations that are needed.

Some of the trends in North Dakota show the number of majors that graduated from the different institutions throughout North Dakota from 1972-1982. (Table 1) At all institutions there has been a downward trend of students majoring in teacher education, such as Dickinson State - 20 in 1972 and down to 4 in 1982. Minot State shows the same trend as well as Mayville and UND. In Biology, there were 41 majors in 1972 and only 16 in 1982. Likewise in Math, there were 62 majors in 1972 and only 22 in 1982. You can see the number of science teachers that have been produced within the state for the last 10 years has been declining.

I do want to report, though, within my science methods class that the trend has now reversed. I hit my low enrollment three years ago where there were only two people in the science methods class. Normally, at least from 1966 to 1972, we had from 10 to 14 students. The enrollment declined to a low of two students in 1979 and gradually has increased to the 14 students presently enrolled. As I see it, the trend is being reversed and is going to continue to change because of the publicity received and also the availability of jobs. It definitely depends on knowing that there is a market for the science and math educator.

As far as requirements for majors, I feel that the teachers from North Dakota have been well prepared and are going out to the schools qualified. Perhaps unqualified majors occur in some other states, but I don't think that it occurs in most higher education institutions in North Dakota. As an example of that type of thing, we're rather unique in North Dakota, since we cannot produce a teacher to teach only one subject. You have to produce a teacher that can teach chemistry, physics, general science, life science, physical science, and earth science. In most North Dakota schools teachers have four preparations during a particular year. We do not have very many schools in this state where a biology teacher only teaches biology, except for Bismarck, Grand Forks, Fargo, Minot, and a few others. As such, teachers need

a good overall science background. For the biology major at NDSU, we do stress the content, as well as educational methods. For the teaching career, the student must have 54 quarter hours in biology, 25 hours of chemistry, a full year of geology; a full year of physics, and math through calculus, statistics, and computer science. To me that's a solid background for science teaching. We also have a composite science major that fits into the junior high area as well as for teaching in high school. With the composite science major you end up with approximately five minors: biology, chemistry, physics, earth science, and math.

Recommendations would include increased salaries, increased financial aid for updating existing teachers, and a federal allocation, such as $3000 per math and science instructor to do as they see fit to improve their own teaching abilities.

In summary, I feel that the majority of North Dakota science teachers (at least those prepared as science majors) are well qualified for their role as professional teachers. In addition, the preparation, number, and overall quality of those going into the science and math area are improving.

A survey on North Dakota math and science teachers is being conducted by graduate students at NDSU. Results will be available in 1984.

Table 1. Math-Science education majors at North Dakota colleges and universities, 1972-1982.

	71-72	72-73	73-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	Totals
NDSU												
Biology	10	11	2	6	2	3	6	5	3	1	3	52
Composite Science	0	0	0	0	0	1	4	1	2	3	0	11
Chemistry/Physics	1	2	1	1	1	0	1	0	0	0	0	7
Math	7	6	6	3	3	2	5	4	2	0	4	42
Jamestown College												
Biology	0	0	0	0	0	0	3	1	0	0	1	5
Composite Science	0	0	0	0	0	0	0	0	0	0	0	0
Chemistry/Physics	0	0	0	0	0	0	0	1	1	0	0	2
Math	0	0	0	0	0	0	0	1	2	1	0	4
Valley City State												
Biology	-	11	10	4	18	3	9	10	4	2	4	75
Composite Science	-	16	0	0	0	0	0	3	5	3	1	28
Chemistry/Physics	-	4	3	1	3	1	1	2	1	2	1	19
Math	-	0	10	4	10	4	5	6	4	6	5	54
Dickinson State												
Biology	13	4	8	8	3	3	3	3	3	5	2	55
Composite Science	9	2	2	0	2	0	1	0	0	0	1	17
Chemistry/Physics	1	2	3	3	1	3	1	0	1	0	0	15
Math	20	15	18	6	8	9	5	11	4	0	4	100
Minot State												
Biology	7	5	8	13	2	5	2	4	0	1	2	49
Composite Science	2	8	8	8	0	3	1	5	2	2	2	41
Chemistry/Physics	1	2	4	8	0	0	0	0	0	0	0	15
Math	18	12	21	17	4	3	2	1	3	3	1	85
Mayville State												
Biology	-	2	5	1	3	1	6	1	2	6	0	27
Composite Science		6	6	2	4	2	4	2	4	2	1	33
Chemistry/Physics		0	0	0	0	0	0	0	0	0	0	0
Math	-	18	20	9	9	8	7	3	5	3	1	83
UND												
Biology	-	8	5	6	4	4	6	6	6	8	4	57
Composite Science	-	-	-	-	-	-	-	-	-	-	-	-
Chemistry/Physics	-	6	3	3	2	2	2	2	3	3	3	29
Math	-	11	9	12	7	7	5	6	9	3	7	75
Totals												
Biology	-	41	38	38	32	19	35	30	18	23	16	290
Composite Science	-	32	16	10	6	6	10	11	13	10	5	119
Chemistry/Physics	-	16	14	16	7	6	5	5	6	5	4	84
Math	-	62	84	51	41	33	29	32	29	16	22	398

THE RISE AND FALL OF TWENTY-FIVE YEARS IN SCIENCE EDUCATION: 1957-1982

Clarence E. Thompson
Science Teacher, Grand Forks Central High School

I began teaching in the sciences in 1957. Twenty-five years have passed quickly and it is hoped that the views expressed will be the impetus for increasing our interest in improved science teaching.

In recent months concern has been expressed over the declining numbers of students studying science, quality of science teaching, numbers of qualified public school science and mathematics teachers, and federal and state support for science education activities. Consequently, we are in both hopeful and frustrating times for those who want to improve science and mathematics education.

A quote from Mr. Rutherford, who is chief education officer for the American Association for the Advancement of Science (AAAS), closely encompasses my thoughts on declining participation in science. (Wall Street Journal, 21 March 1980)

> "Captured by television and the entertainment industry, far too many students seem to show reduced attention spans, underdeveloped reading and writing skills and negative attitudes toward demanding subjects. They lack motivation to study science and mathematics, often because those subjects are made boring, but also because peer pressure and school climates are frequently unfavorable to the pursuit of excellence."
>
> "Students don't see that science is important to them personally, and neither do many of their parents, teachers or school counselors."

1957 and 1958 began the emergence of increased science training through NSF (National Science Foundation) institutes. Competency through content, teaching techniques, improved laboratory facilities and equipment came into the secondary schools, colleges and universities. This stimulated faculty and students to increased competency and pride in being knowledgeable in science.

As we progressed into the 60's the increased demands on students to perform at higher levels and the Vietnam war was met with the question of "relevancy" and "do your own thing" view regarding subject matter content. The societal demands, of the 60's and reaching into the 70's, are difficult to measure. Therefore, I want to relate some of the developing circumstances that are of concern to the scientific community:

- Interest of students pursuing science careers declined and then fortunately, increased in engineering fields.

- There was, and still is, an erosion of faculty to other professions.
- Declining test scores in the sciences.
- A lack of skills in reading, writing and making computations.
- The emotional demands of teaching take their toll. Many secondary teachers will reiterate the existing discipline problems and the lack of direction that exists for some students.
- After several years of teaching the teacher realizes the intellectual challenge is inadequate at the secondary level.
- Grade inflation has crept into the grading process at many secondary and postsecondary schools.

Earlier, declining test scores were mentioned. ACT scores for the natural sciences for Grand Forks Central and North Dakota are compared. (Table 1)

Table 1. AMERICAN COLLEGE TEST High School Profile Report 1981-82

	Central (127 students) (95)*	North Dakota (6589 students) (4278)*	Nation
Composite	18.7	17.8	18.4
English	17.7	17.2	
Math	18.1	16.0	
Social Studies	17.1	16.8	
Natural Science	21.2	20.7	

MEN	Central (57 students)	North Dakota (3009 students)
Composite	18.6	18.5
English	16.5	16.4
Math	18.3	17.4
Social Studies	17.5	17.6
Natural Science	21.8	22.0
	24.3*	22.1*

Women	Central (70 students)	North Dakota (3580 students)
Composite	18.7	17.3
English	18.6	17.9
Math	17.9	14.9
Social Studies	16.9	16.2
Natural Science	20.7	19.7
	21.8*	20.9*

*1969-70 Central

The Natural Science scores for Central High School in 1981-82 shown are above the national score of 18.4. The 1969-70 scores are higher and showed a decline in 1981-82 but yet are above the national average of 18.4.

Results of a questionnaire given to seniors at Central High School and Red River High School regarding courses of most value to you while attending high school demonstrate that students value mathematics (Table 2). A similar situation is indicated by the two science courses at Central High School.

Table 2. What courses were of most value to you while you were attending high school?

Red River High School	Central High School
a. Mathematics	a. Mathematics
b. English and Composition	b. Medical Biology and Chemistry Study
c. Psychology and Sociology	c. Typing

At this point it can be said that it is not necessarily the material you teach the student. Is the material a body of knowledge that will enable the student to continue in science education with a respectable measure of success? One other comment will suffice: If the instructor sets high standards and adheres to them, the students will very likely achieve those standards. Students will tell you, within a year or two after graduation, that the course could have been more difficult.

Two approaches to teaching will illustrate relevency without having the student confronting the teacher regarding "Why do we have to know this?" Whether the student is a non-science major or a science major or a high school student, I have found success using genetics as an example of dispelling the concept of unrelated facts that students literally abhor. Any success I have encountered in creating an element of scientific literacy is based upon teaching the basic principles of genetics. Then center the teaching and discussion on human genetics and human characteristics, genetic diseases and birth defects--something a non-science student can identify.

I use a similar principle with the advanced class of seniors at the high school. Development of the human nervous system during the critical stage of embryogenesis, for example, during the first 30 days of pregnancy and the effects of drugs, genetics, and the environment on neural tube defects is found to intrigue the students. In both examples, the genetics and the nervous system defects, the ethical problems can be addressed should the instructor and/or students desire to do so.

We are fortunate in North Dakota to have an Academy of Science that is celebrating its 75th year. The Senior Academy has given support to the Junior Academy of Science, which, in itself, is a strength of science in North Dakota. The Junior Academy of Science is in its 12th year. We have sponsored:

- The North Dakota high school symposium in conjunction with the Senior Academy. This year 14 students will present papers.

- Scientific research project with: 1st place $200.00 George Abbott Scholarship paid to a North Dakota college of choice; plus a $75.00 cash Dunbar Award. 2nd place $100.00 Abbott Scholarship, plus a $50.00 cash Henderson Award. An Honorable Mention is also given.
- Minnesota Junior Academy participation.
- Poster displays which began last year at our Bismarck, ND meeting.
- Minigrants: financial support for research through the Science Education Committee of the North Dakota Academy of Science. Funds are made available through an AAAS grant and are distributed in grants of $10.00 to $80.00.
- International Science and Engineering Fair.
- Science Talent Search for Westinghouse Scholarships.

In summary I would like to submit some priorities for science education.

One, strengthen the curriculum and graduation requirements in our high schools. (Be sure to include a computer course as an additional requirement.)

Two, we all know certain people are natural teachers of complex subjects. Let's capitalize on their talents. These teachers could be used in the magnet schools concept in larger population centers.

Three, upgrade the pay levels of science and math teachers and the engineering professors in our vocational, secondary schools, and universities so that they are competitive with industry. There will be objections raised if science teachers are paid higher than the salary schedule permits. Rather, compensation could be paid, as a bonus to science teachers who work for industry or participate in training programs, at the end of a succeeding school year.

Four, and an equal priority would be to upgrade teaching labs at the high school and college levels. For example, teachers must get into the non-bookishness of science and use the microscope instead of pictures in a book.

Five, provisions need to be made enabling secondary science teachers to be updated in new knowledge and technology through the colleges, universities, and industry. This is the best way for credibility to be maintained between student and teacher in this, our most urgent endeavor, science teaching.